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AH-1G HELICOPTER 19-ROUND LIGHTWEIGHT AIRBORNE LAUNCHER JETTISON ENVELOPE DETERMINATION.

9

FINAL REPORT.

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11

MARCH 1979

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UNITED STATES ARMY AVIATION ENGINEERING FLIGHT ACTIVITY
EDWARDS AIR FORCE BASE, CALIFORNIA 93523

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2.75" Rocket Launcher Jettison
AH-1 Jettison Envelope
2.75" Lightweight Launcher
Jettison Range Facilities
High Speed Jettison Photography

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The United States Army Aviation Engineering Flight Activity conducted a limited evaluation of a 19-round prototype launcher to determine a safe jettison envelope for the 19-round lightweight airbrone rocket launcher. The evaluation was conducted from 25 May 1978 to 6 June 1978 at Edwards Air Force Base, California. Ten flights using an AH-1G helicopter were conducted totaling 3.5 flight hours. This evaluation defined a safe jettison envelope in coordinated (ball-centered) level flight to 120 knots calibrated airspeed (KCAS) and in autorotation at 70 KCAS. Estab-

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20. Abstract

CONT → lishment of a jettison envelope equivalent to that of the M159 and M200 launcher will require 75 7-round and 75 19-round lightweight airborne rocket launchers and 744 2.75-inch Model M229 rockets. Five reliability and maintainability launcher shortcomings were identified during the evaluation of the prototype launcher.

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DEPARTMENT OF THE ARMY
HQ, US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
P O BOX 209, ST. LOUIS, MO 63166

DRDAV-EQ

19 MAY 1979

SUBJECT: Director of Development and Engineering Position on the Final Report of USAAEFA Project No. 78-10, AH-1G Helicopter 19-Round Lightweight Airborne Launcher Jettison Envelope Determination, March 1979

SEE DISTRIBUTION

1. The purpose of this letter is to establish the AVRADCOM position on the subject report. It should be understood that the Lightweight Launcher (LWL) utilized during this test was a prototype model (See Appendix B for differences). In addition to the jettison envelope portion of the evaluation, the test directive required AEFA to determine qualitatively any changes in handling qualities of the AH-1 due to the LWL. While the report does not specifically address this subject, discussions with AEFA personnel indicate that no differences in flying qualities were discernible to the pilot, thus the conclusion of compatibility was made (See paragraph 20).

2. Paragraph 6 stated that the criterion for determining the critical launcher loading was that configuration that allowed the launcher to remain the closest to the helicopter for the longest period of time. Paragraph 10 states that an empty launcher had a jettison velocity of 23 ft/sec and that the critically loaded launcher, one rocket in launcher, had a jettison velocity of 19 ft/sec as stated in paragraph 11. The launcher with the lowest jettison velocity will be the launcher that remains the closest to the helicopter. In view of the above, the fully loaded launcher will weigh the most and consequently will have the lowest jettison velocity. This means the fully loaded LWL will be the most critical by the AEFA definition. (NOTE: This was not flown in forward flight.) The launcher that has the greatest tendency to fly is the empty launcher because it is the lightest. If the one rocket was placed in the bottom row at the inboard most location, the result would be a right roll which would result in less clearance. It appears that the most critical LWL was not tested. The critical launcher would result in a roll mode into the helicopter.

19 MAY 1979

DRDAV-EQ
SUBJECT: Director of Development and Engineering Position on the Final Report of USAAEFA Project No. 78-10, AH-1G Helicopter 19-Round Lightweight Airborne Launcher Jettison Envelope Determination, March 1979

3. This Headquarters agrees with the conclusions and recommendations of the report, except that we consider the inability to attach the LWL to the outboard stores stations a major design discrepancy, (See paragraph 18). Action planned to correct each shortcoming listed in paragraph 21 is as follows:

a. On production launchers, the lug attachment distance from the outer skin of the LWL to the bottom of the lug is increased from 1.00/1.08 to 1.15/1.25 inches. This increased distance will now allow the LWL to be installed on the outboard stores station. This modification also alleviates the shortcomings associated with the locknut and adjustment bolts of the sway brace pads with the increased clearance provided in the production LWL.

b. The inability to close the store rack fairing with the electrical umbilical cord connected was cited as a shortcoming. On the production LWL the electrical connector is located at the same relative position as that on the M200 launcher, which is currently being used. This will allow the closing of the store rack fairing.

c. A shortcoming was associated with the possibility of the electrical connector plate becoming detached due to an inadvertent jettison. The launchers used in this test were fabricated as "jettison" launchers and were representative of the production LWL in size, shape, and mass. The structural characteristics of the "jettison" launchers used in this test are not necessarily representative of production LWL, i.e., the connectors on the production launcher are fastened to the LWL more efficiently.

4. Further testing is planned for summer 1979 to complete the jettison envelope for full operational use. The issue of paragraph 2 above will be addressed during that test.

FOR THE COMMANDER:

WALTER A. RATCLIFF
Colonel, GS
Director of Development
and Engineering

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INTRODUCTION

BACKGROUND

1. Lightweight airborne rocket launchers (LWL) in seven and 19-round (rd) capacity are being developed for incorporation into the armament system of the AH-1 series helicopter and the advanced attack helicopter. Testing had been limited to laboratory developmental testing and minimal flight evaluation utilizing the AH-1G helicopter. To ensure that a safe jettison capability exists during the Army's production qualification testing the United States Army Aviation Research and Development Command (AVRADCOM) directed the United States Army Aviation Engineering Flight Activity (USAAEFA) to develop a limited jettison envelope for the 19-rd LWL (ref 1, app A). Test models fabricated by Hughes Aircraft Company which simulated the aerodynamic and weight characteristics of the 19-rd LWL were used in this determination.

TEST OBJECTIVES

2. The objectives for the LWL test were as follows:

a. Establish a limited flight jettison envelope for the 19-rd LWL with eight 19-rd prototype AWL.

b. Determine the number of LWL's required to expand the jettison envelope to be equal to that of the M159 and M200 launchers.

DESCRIPTION

3. The test helicopter was a standard AH-1G helicopter, SN 71-20985, incorporating a nose-mounted instrumentation boom. A detailed description of the helicopter is contained in the operator's manual (ref 2, app A). A high-speed, 16mm motion picture camera was mounted on an external camera pedestal at fuselage station (FS) 65 on the right side of the helicopter. A description of the 19-rd LWL and the test model is contained in appendix B.

TEST SCOPE

4. The 19-rd LWL jettison test was conducted at Edwards Air Force Base, California. Ten flights totaling 3.5 flight hours were flown from 25 May to 6 June 1978. Photographic coverage was provided by the Edwards Air Force Base photography facility. Flight restrictions and operating limitations were established by the operator's manual and modified by the airworthiness release issued by AVRADCOM (ref 3, app A). Eight test model LWL's were supplied to establish a limited jettison

envelope to comply with the requirements established in AMCP No. 706-203 (ref 4). Testing included static jettison (engine OFF), hover jettisons (2-foot skid height), level flight jettisons up to 120 knots calibrated airspeed (KCAS), and 70 KCAS partial power descent and autorotation jettisons. Forward flight jettisons were conducted in coordinated (ball-centered) flight, approximately 3000 feet above the surface (average density altitude of 7000 feet), an average gross weight of 8000 pounds, a forward longitudinal center of gravity (cg) at FS 194, a lateral cg at buttline (BL) 0.7 right of center, and a main rotor speed of 324 rpm.

TEST METHODOLOGY

5. Jettison tests were conducted by stabilizing the helicopter at the desired initial conditions and then jettisoning a 19-rd LWL test model from the right inboard stores station. The right inboard station was identified by AVRADCOM in their test request and their analytical study to be the critical stores location in forward flight. Photo coverage was provided from high-speed, 400 frames per second, motion picture cameras mounted on the test aircraft and aboard a chase helicopter. These cameras recorded the launcher's jettison and flight characteristics and clearance from the test helicopter. An analysis of the film was conducted prior to continuing to the next point in the build-up sequence of airspeed and rate of descent (R/D).

RESULTS AND DISCUSSION

GENERAL

6. A limited evaluation was conducted to determine a safe jettison envelope for the 19-rd LWL. Three LWL loadings were considered as having the greatest probability of not meeting the requirements of AMCP No. 706-203. Of these three configurations, the LWL with one 2.75-inch rocket in the outboard tube of the top row was considered the most critical. The criterion for criticality was the configuration that allowed the launcher to remain in vicinity of the helicopter for the longest period of time with the greatest probability to be influenced by aerodynamics (fly) and possibly hit aft portions of the helicopter. During the tests, the 19-rd LWL model exhibited satisfactory jettison characteristics. These tests defined a jettison envelope in coordinated (ball-centered) level flight to 120 KCAS and in autorotation at 70 KCAS. Five reliability and maintainability shortcomings on the prototype launcher were identified during this evaluation. Within the scope of this evaluation, the requirements of AMCP No. 706-203 were met.

JETTISON TESTS

Static Jettison

7. An empty LWL was jettisoned from the right inboard stores station with the helicopter on the ground and the engine OFF. Jettison was initiated from the gunner station. After separation from the ejector piston pad, the LWL pitched nose down, yawed to the right (away from the aircraft), and rolled to the left (counterclockwise, looking forward). The LWL did not contact the helicopter.

Hover Jettison

8. Three differently loaded LWL's (fig. 1) were jettisoned at a 2-foot skid height during the hover tests. Jettison was initiated from the gunner station. None of the LWL's struck the helicopter during jettison. The empty LWL yawed to the right, pitched nose down at a rate of 70 deg/sec, and rolled left at 130 deg/sec. The closest distance the launcher came to the skid during jettison was 12 inches. The LWL with one 2.75-inch rocket loaded in the outboard tube of the top row of launcher tubes yawed to the right, developed a nose-down pitching rate of 40 deg/sec, and a left roll rate of 270 deg/sec. The closest distance the LWL came to the skid during jettison was 15 inches. The LWL with 19 2.75-inch rockets yawed to the right, pitched nose up at a rate of 10 deg/sec, and rolled right at 80 deg/sec. During jettison, this LWL came the closest to the skid of the three launcher loadings. This distance was 4 inches. Within the scope of this test, the jettison characteristics of the LWL during hover are satisfactory.

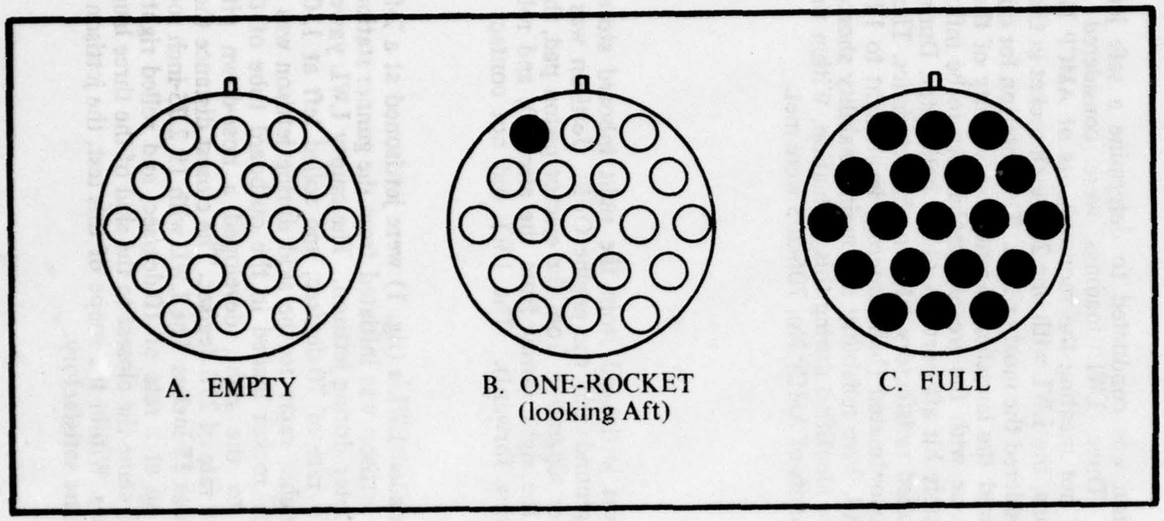

Figure 1. LWL Test Loadings.

Level Flight Jettison

9. Four jettisons were conducted at airspeeds ranging from 68 to 120 KCAS in level flight. The LWL's shown in figure 1 (a and b) were jettisoned at approximately 70 KCAS and a comparison of the jettison characteristics of the two were made. The launcher configuration analytically determined to be the most critical (para 6) was empirically confirmed and used for the remainder of the jettisons. The fully loaded launcher was eliminated from further testing as the possibility to fly aerodynamically was unlikely because of its weight. The pilot initiated one of the four jettisons and the gunner initiated the remainder. At no time during this evaluation did the location (pilot or copilot/gunner station) from which the jettison was initiated have any noticeable effect on the jettison characteristics of the LWL. No LWL struck the helicopter during jettison.

10. During jettison at 70 KCAS the empty launcher pitched nose down, yawed right, and rolled slowly to the left. The jettison velocity of the empty LWL was 23 ft/sec, and it cleared the skid by 13 inches. The clearance at 70 KCAS was essentially the same as that in a hover. The jettison characteristics of the empty LWL at 70 KCAS in coordinated (ball-centered) flight are satisfactory.

11. A critically loaded launcher was jettisoned at airspeeds from 68 to 120 KCAS. During jettison at all airspeeds, the launcher pitched nose down, yawed right, and rolled left. At 68 KCAS, jettison velocity was 19 ft/sec, a reduction of 4 ft/sec as compared to the empty LWL. Jettison velocity of the critically configured launcher was independent of airspeed throughout the airspeed range tested. Clearance between launcher and skid averaged 16 inches and was essentially unchanged from hover to 120 KCAS. Within the scope of this test, the jettison characteristics of the critically loaded launcher at airspeeds up to 120 KCAS in coordinated (ball-centered) level flight are satisfactory.

Partial Power and Autorotational Descent Jettison

12. Partial power descent jettisons were used as a build-up for the autorotational jettison. Partial power descent jettisons were conducted at an average of 70 KCAS and at rates of descent of 600 and 1400 ft/min. The pilot initiated the jettison at 600 ft/min R/D and the gunner initiated the other two. The critically loaded LWL was used for these jettisons. No LWL struck the helicopter during jettison. During partial power descent and autorotational jettisons the LWL initially pitched nose down, yawed right, and rolled to the left. As rate of descent increased, nose-down pitch rate decreased. Clearance distance between launcher and skid was 16 inches and jettison velocity was 18 ft/sec. Jettison velocity and clearance between launcher and skid of the critically configured launcher are independent of R/D at 70 KCAS. Within the scope of this test, the jettison characteristics of the LWL during partial power and autorotational descent at 70 KCAS in coordinated (ball-centered) flight are satisfactory.

RELIABILITY AND MAINTAINABILITY

Ejector Stores Rack

13 Factors discussed in this paragraph pertain to the attachment of the LWL to the AH-1G helicopter. This helicopter had ejector stores rack, manufacturer's part No. 209-071-080-3, on the left inboard stores station and manufacturer's part No. 209-071-080 on the right inboard and both outboard stores stations. Prior to attaching the test model LWL, the ejector stores racks were set according to procedures listed in reference 5, appendix A.

14. The sway braces of the ejector stores racks consist of four pylon fittings and four sway brace pads. The sway brace pad includes a 4-inch threaded adjustment bolt, a locknut (AN 316-6R), and a 2-inch diameter pad. Prior to attaching the LWL, the locknut is threaded on the adjustment bolt as far as possible toward the pad and then the adjustment bolt is threaded all the way into the pylon fitting. The sway brace pads available for this test were not identical, in that the adjustment bolts were threaded to different lengths (photo A). Those that were not threaded to the end could not be used, as the LWL could not be attached to the ejector stores rack due to insufficient clearance. Insufficient clearance existed between the launcher and the aft sway brace pads for the inboard stores pylon and between the launcher and the ejector piston pad for the outboard stores pylon. The incomplete threading of the adjustment bolts of the sway brace pads is a shortcoming.

15. The edges of the standard locknut (AN 316-6R) used on the sway brace pads rounded with normal use. This occurred because of the thinness of the locknut (photo B) and the lack of sufficient clearance between the pylon fitting and the sway brace pad adjustment bolt head for a standard size wrench, when the locknut was threaded as far up as possible on the adjustment bolt. Maintenance personnel had to periodically replace them to ensure proper security and adjustment of the LWL. This replacement increased the time required to mount the LWL. It should be noted that increasing the thickness of the locknut will further decrease the clearance necessary for mounting the LWL as mentioned in paragraph 14. The tendency for the sway brace pad locknut (AN 316-64) to round during normal use is a shortcoming.

Electrical Connectors

16. Two electrical connectors are mounted on the top of the LWL to provide DC power for rocket firing. The center line of the forward and aft electrical connectors on the LWL are located 6 inches and 3 1/4 inches, respectively, forward of the front attaching lug (photo C). When the electrical umbilical cord of the external stores rack is connected to either electrical connector, the fairing on the nose of the external stores rack could not be closed (photo D). The inability to close the stores rack fairing with the electrical umbilical cord connected is a shortcoming.

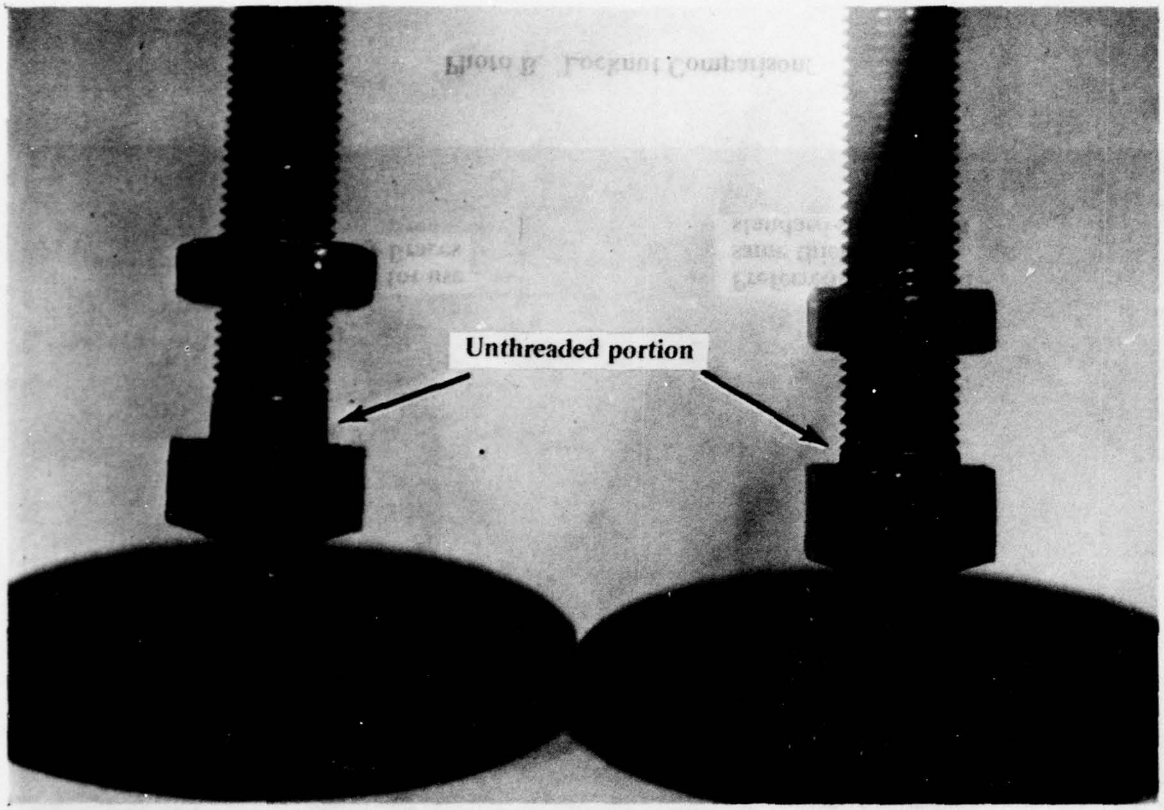

Photo A. Sway Brace Pads.

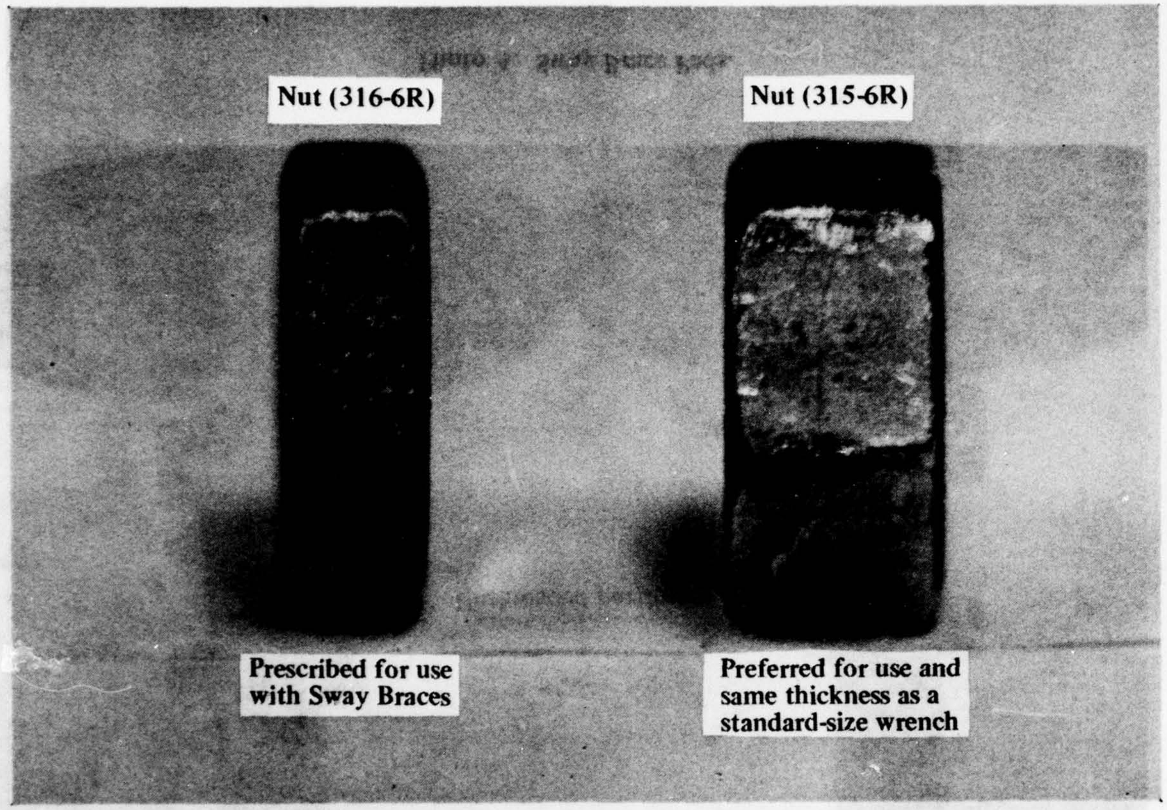

Photo B. Locknut Comparison.

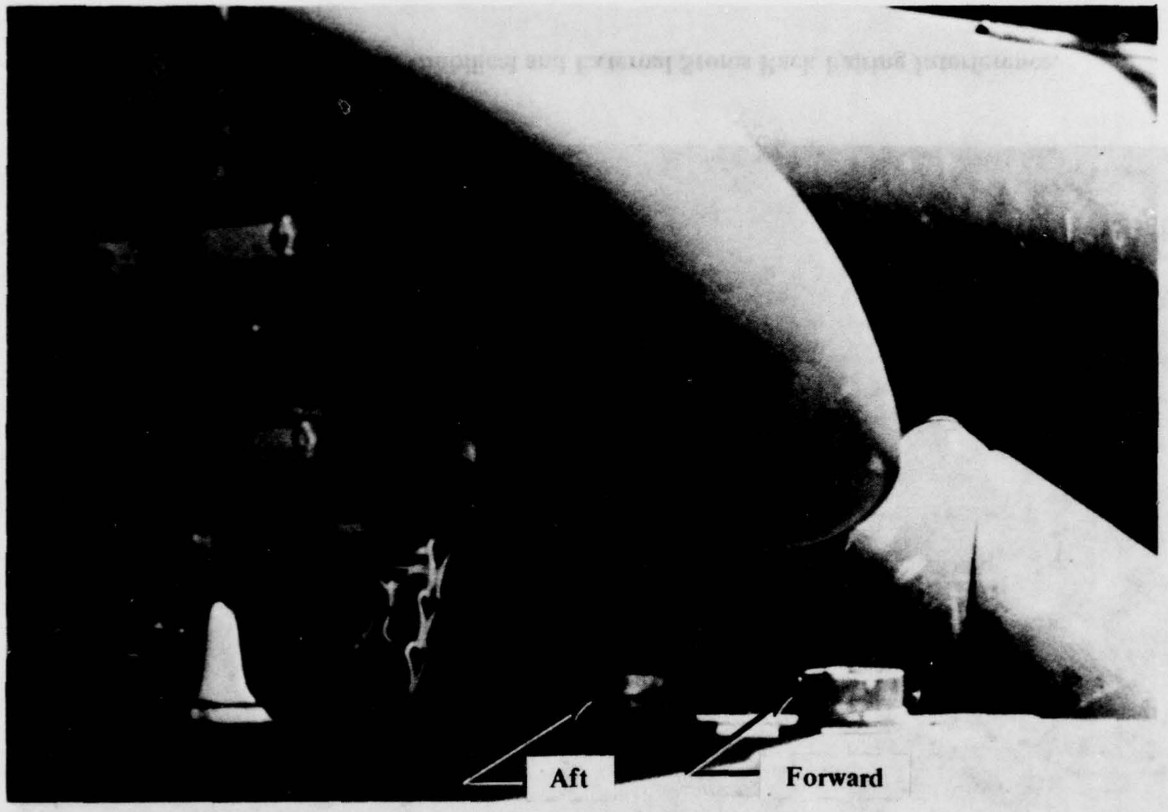

Photo C. LWL Electrical Connector Locations.

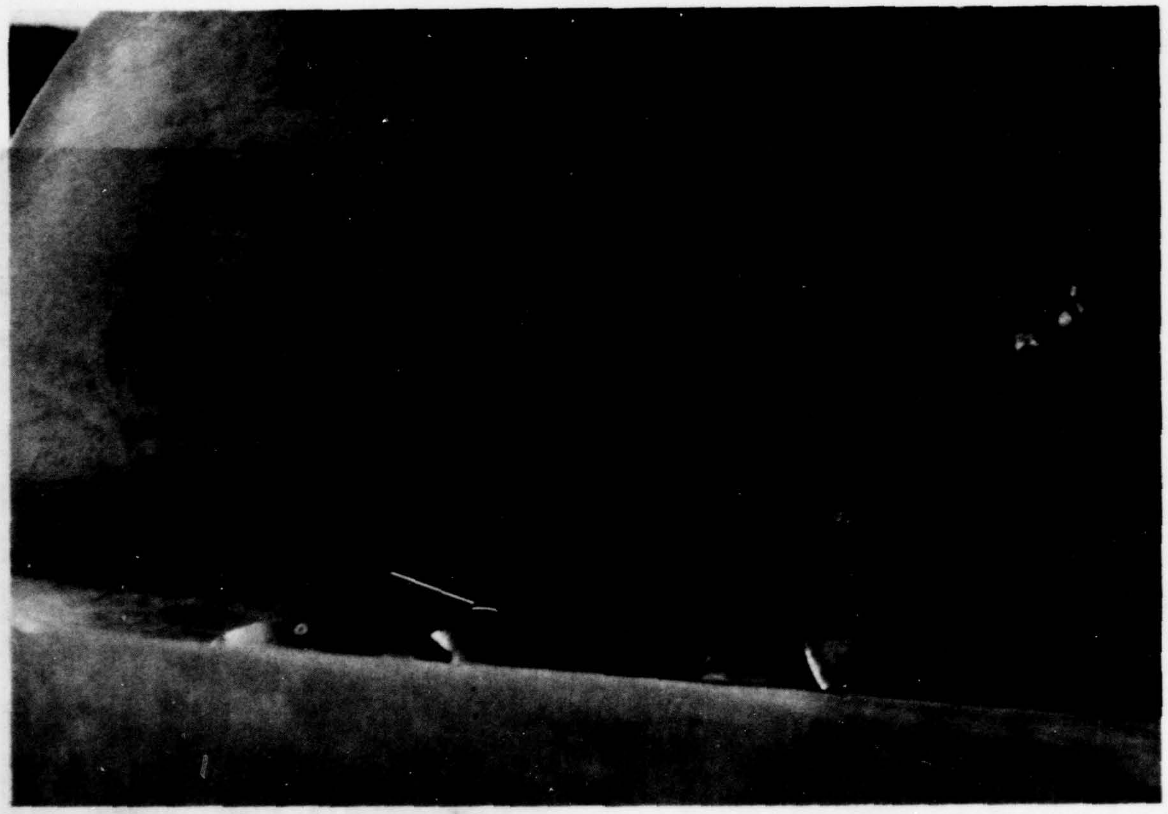

Photo D. Electrical Umbilical and External Stores Rack Fairing Interference.

17. The electrical connectors are attached to an oval plate that is glued to the outer skin of the LWL. During three out of ten jettisons, the electrical connector plate was pulled off the LWL. Operationally, an inadvertent static jettison by maintenance or flight personnel could destroy the electrical integrity of the LWL and render it inoperative. The possibility of the electrical connector plate becoming detached due to an inadvertent jettison is a shortcoming.

Attachment Lugs

18. The attachment lugs were screwed into the test model LWL until the distance from the outer skin of the LWL to the bottom of the horizontal portion of the lug was from 1.00 to 1.08 inches (fig. 2). The attachment lugs of the production LWL are to be permanently set within these tolerances. The lug heights of the model LWL that produced the greatest mounting clearance were measured to be 1.08 inches and 1.06 inches, forward and aft, respectively. This LWL could not be attached to either outboard stores station. The ejector piston pad of the outboard bomb rack extends out too far to allow the LWL to be locked into position (photo E). The inability to attach the LWL to the outboard stores stations is a shortcoming.

REQUIREMENTS FOR FULL ENVELOPE DETERMINATION

19. Development of a LWL jettison envelope comparable to that of the M200 launcher will require approximately 75 7-rd and 75 19-rd LWL's, and 744 2.75-inch rockets. These quantities will be sufficient to evaluate the complete airspeed envelopes. the sideslip envelopes corresponding to 0.1g lateral side force (ref 6, app A), and the LWL loading most critical for each flight regime. Jettison and rotational velocities appear to affect launcher clearance from the aircraft, and these parameters are dependent upon launcher loading. Launcher and rocket requirements by flight condition are shown in table 1.

Table 1. Requirements for Envelope Expansion

Flight Description	19-Round LWL		7-Round LWL	
	Launcher	Rockets	Launcher	Rockets
Forward	29	189	28	61
Descending	18	123	20	61
Climbing	9	80	9	32
Autorotational	19	142	18	56
Total	75	534	75	210

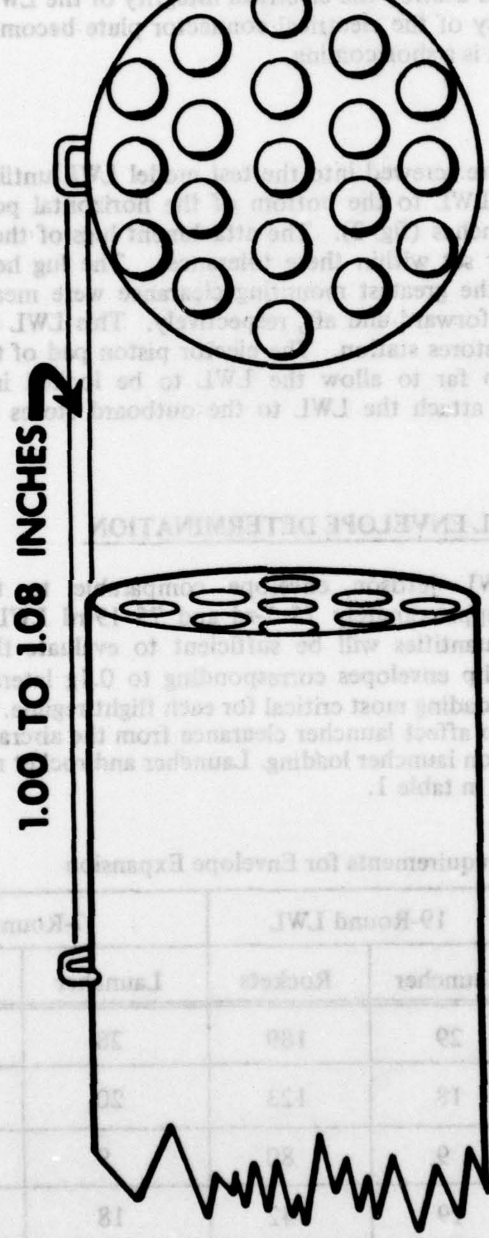

Figure 2. Attachment Lug Tolerances.

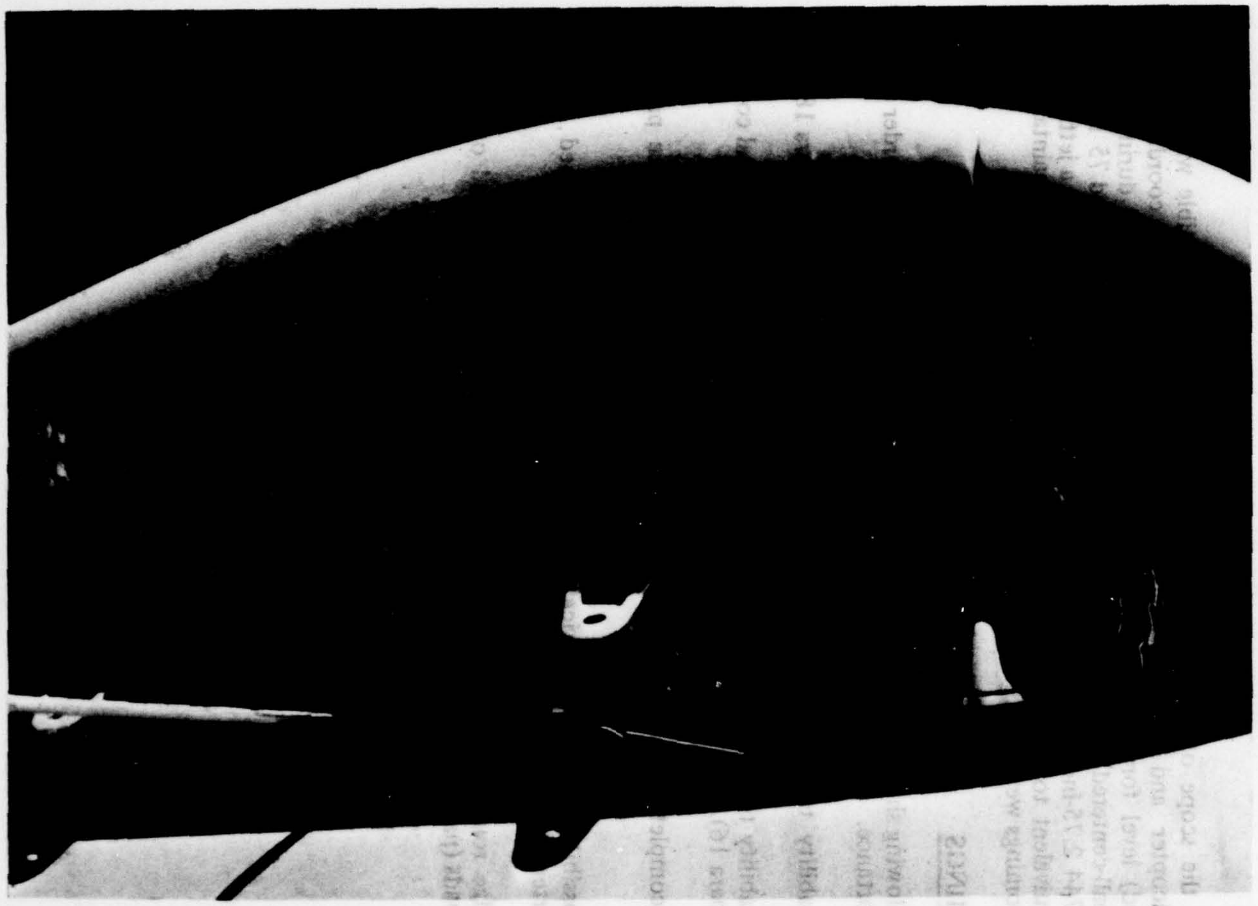

Photo E. LWL Mounting Interference On Outboard Stores Station.

CONCLUSIONS

GENERAL

20. Within the scope of this evaluation, the 19-rd LWL is compatible with the AH-1G helicopter and can be safely jettisoned at a hover, in coordinated (ball-centered) level forward flight at airspeeds up to 120 KCAS, and during coordinated (ball-centered) autorotation at 70 KCAS. A total of 75 7-rd and 75 19-rd LWL's and 744 2.75-inch Model M229 rockets are required to determine a jettison envelope equivalent to that of the M200 launcher. Five reliability and maintainability shortcomings were identified.

SHORTCOMINGS

21. The following shortcomings were identified and are listed in decreasing order of relative importance.

a. Inability to attach the LWL to the outboard stores stations (para 18).

b. Inability to close the stores rack fairing with the electrical umbilical cord connected (para 16).

c. Incomplete threading of the adjustment bolts of the sway brace pads (para 14).

d. Possibility of the electrical connector plate becoming detached due to an inadvertent jettison (para 17).

e. Edge rounding characteristics of the locknut, AN 316-6R, used on the sway brace pads (para 15).

RECOMMENDATIONS

22. The shortcomings reported in paragraph 21 should be corrected.

23. The jettison envelope of the 19-rd LWL should be limited to airspeeds in coordinated (ball-centered) level forward flight up to 120 KCAS, and 70 KCAS for coordinated (ball-centered) partial power descents and autorotation (para 6).

APPENDIX A. REFERENCE

1. Letter, AVRADCOM, DRDAV-EQI, 28 April 1978, subject: 2.75 Inch Rocket Lightweight Launcher (LWL) Jettison, AH-1.

2. Technical Manual, TM 55-1520-221-10, *Operator's Manual, Army Model AH-1G Helicopter,* 12 December 1975, with Change 6, 16 January 1978.

3. Letter, AVRADCOM, DRDAV-EQI, 19 May 1978, subject: Airworthiness Release for 2.75 Inch Rocket Lightweight Launcher Jettison, AH-1.

4. Army Materiel Command Pamphlet, AMCP No. 706-203, *Engineering Design Handbook, Helicopter Engineering Part Three, Qualification Assurance,* April 1978.

5. Technical Manual, TM 9-1055-460-14, *2.75 Inch Aircraft Rocket Launcher,* October 1973.

6. Final Report, USAASTA Project No. 71-03, *Study Pilot Perceived Jettison Envelope,* June 1973.

APPENDIX B. DESCRIPTION

1. The 19-rd launchers used in this evaluation were models of the 19-rd LWL. The test model was fabricated by Hughes Aircraft Company, Tucson, Arizona, and simulated the aerodynamic and weight characteristics of the 19-rd LWL.

2. The 19-rd LWL consists of the tube cluster, a strongback, attaching hardware, skin, forward and aft bulkheads, and structural plastic foam. The structural plastic foam is used to stabilize the launcher tube locations with respect to the structural strongback, skin, and bulkheads and to retain boresight tolerance throughout the operational life of the launcher. It is also designed to attenuate the vibrations transmitted from the attack helicopter. The launchers have electrical circuits for the firing and fuse setting pulses and incorporate a detent for retention of the rockets in the tubes during transportation and throughout the helicopter's flight envelope.

3. A comparison between the 19-rd LWL and the test model is presented in table 1. Photos 1 and 2 show the test model utilized during the test.

Table 1. Comparison of Launcher Characteristics.

ITEM	19-Round LWL	Model 19-Round LWL
Length (in.)	69.93	71.1
Diameter (in.)	16.01	16.0
Weight (lb)	79.50	85.0
Longitudinal cg location measured from front (in.)	35.56	38.3
Moments of inertia (slugs-ft^2)		
Pitch	5.99	7.1
Roll	0.55	0.6
Yaw	6.15	7.1

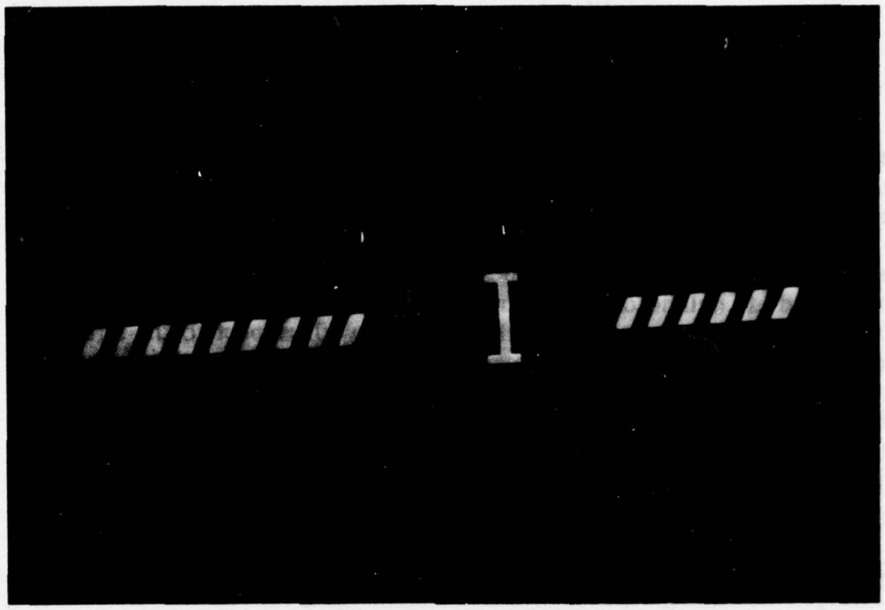

Photo 1. Right Side.

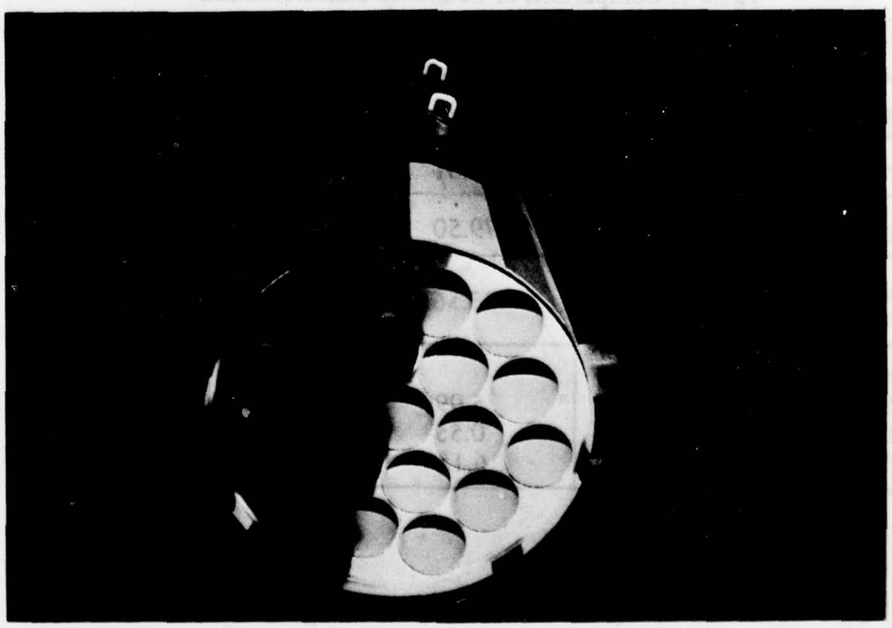

Photo 2. Front.

APPENDIX C. INSTRUMENTATION

GENERAL

1. High-speed 16mm motion pictures were the primary source of data during the evaluation and were provided by two cameras, one mounted on the test helicopter and the other used by an airborne photographer in the chase helicopter. A swiveling pitot-static source and sideslip vane were installed on a boom extending forward from the nose of the helicopter. This boom system provided calibrated indications of airspeed, altitude, and sideslip to the flight test crew.

16MM HIGH-SPEED MOTION PICTURE CAMERA

2. A high-speed 16mm motion picture camera, model DBM-54, manufactured by D.B. Milliken Co., Arcadia, California, was used to provide film documentation of each jettison. This camera incorporated intermittent film transport, positive registration pin, and a variable speed control system with a range from 2 to 400 frames per second. The camera mounted on the test helicopter was powered by 28VDC and was operated remotely through parallel power on-off switches located on the pilot and copilot instrument panels. This camera was equipped with a 10mm wide-angle lens. Physical characteristics of the test mounted camera are noted below.

Length	13-1/2 inches
Width	4-1/4 inches
Width with bore sight	6 inches
Height	7-1/2 inches
Weight	19 pounds

COCKPIT PARAMETERS

3. The following parameters were displayed:

Pilot Panel

Airspeed (boom)
Altitude (ship)
Free air temperature (ship)
Rotor speed (ship)
Fuel quantity (ship)
Sideslip angle (boom)
Rate of Climb (ship)

Copilot Panel

Airspeed (boom)
Altitude (boom)
Rotor speed (ship)
Rate of climb (ship)
Total air temperature

APPENDIX D. DATA ANALYSIS METHODS

1. The analysis of the 16mm motion pictures taken during the evaluation provided clearance between launcher and helicopter, jettison velocity, and pitch and roll velocities. A photo analyzer capable of displaying a single frame of film at a time was used for data reduction.

2. The procedure used to compute the linear and angular velocities was to compare measurements taken from 16mm frames of film 0.025 second apart. These velocities were determined by measuring the trajectory once the launcher separated from the ejector piston pad upon full extension during a 0.05-second time frame. An attempt was made to correct all measurements due to change in launcher image size as distance from the camera varied.

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